Limiting Reagents

Tin (Sn) and iodine (I_2) react to produce tin iodide (SnI_4). If there are 10.00 g of tin and 40.00 g of I_2 at the beginning of the reaction, what is the maximum amount of SnI_4 that may be produced?

What is happening in this reaction? We have iodine, which is a black crystalline solid reacting with tin (a grey-white solid metal solid) to form SnI_4. So the skeleton equation is

$$Sn + I_2 \rightarrow SnI_4.$$

Determine the Limiting Reagent:
#1 Balance the reaction: $Sn + \underline{\mathbf{2}}\ I_2 \rightarrow SnI_4$. In this case, we do not know which reactant is the limiting reagent. In order to find how much product is formed, however, we must determine this.

#2 Assume one reactant is the limiting reagent and determine whether or not there is a sufficient amount of the other reagent(s) for the assumed limiting reagent to react completely.

So to start let's look at Sn and assume for now that it is the limiting reagent. **How much iodine is needed to completely consume 10.00 g of Sn?**

$$\text{mass } I_2 \text{ needed} = 10.00\text{ g Sn} \times \frac{1\text{ mol Sn}}{118.710\text{ g Sn}} \times \frac{2\text{ mol } I_2}{1\text{ mol Sn}} \times \frac{253.810\text{ g } I_2}{1\text{ mol } I_2} = 42.77\text{ g } I_2$$

This means that in order for 10.00 g of Sn to be used completely, 42.77 g of iodine is needed. But we only have 40.00 g of I_2 (i.e., not enough I_2 to completely react with all of the tin). ***This means iodine is the limiting reagent.***

Determine the amount of SnI_4 that may be produced: *We must use iodine for this calculation since it is the limiting reagent.*

$$\text{mass } SnI_4 \text{ produced} = 40.00\text{ g } I_2 \times \frac{1\text{ mol } I_2}{253.810\text{ g } I_2} \times \frac{1\text{ mol } SnI_4}{2\text{ mol } I_2} \times \frac{626.330\text{ g } SnI_4}{1\text{ mol } SnI_4} = 49.35\text{ g } SnI_4$$

Prove to yourself that iodine is the limiting reagent. How much product could be produced from 10.00 g of Sn (assume that tin is the limiting reagent)?

Determine the amount of compounds remaining when the reaction is complete: What remains in the reaction container after the reaction has been completed? There is no iodine, only Sn and SnI_4. We have already calculated how much SnI_4 is produced, but how much tin is left?

$$\text{mass Sn used} = 40.00\text{ g } I_2 \times \frac{1\text{ mol } I_2}{253.810\text{ g } I_2} \times \frac{1\text{ mol Sn}}{2\text{ mol } I_2} \times \frac{118.710\text{ g Sn}}{1\text{ mol Sn}} = 9.354\text{ g Sn}$$

$$\text{remaining Sn: } 10.00\text{ g Sn} - 9.354\text{ g Sn} = 0.65\text{ g Sn}$$

So after the reaction has taken place, we would expect 49.35 g of SnI_4 and 0.65 g of Sn in the reaction container.

Alternate approach:
You can also use a mole ratio approach: Sn + **2** I_2 → SnI_4
Tin (Sn) and iodine (I_2) react to produce tin iodide (SnI_4). If there are 10.00 g of tin and 40.00 g of I_2 at the beginning of the reaction, what is the maximum amount of SnI_4 that may be produced?

#1 find moles of tin each reactant that you:

$$10.00g\ Sn\ \times \frac{1molSn}{118.7g\ Sn} = 0.0842moles\ Sn$$

$$40.00g\ \text{I2}\ \times \frac{1\ mol\ \text{I2}}{253.81g\ \text{I2}}\ =\ 0.158\text{mols I2}$$

#2 Divide by molar coefficient in balanced equations: **1** Sn + **2** I_2 → **1** SnI_4

$$\frac{0.0842mole\ Sn}{1\ mole\ Sn} = 0.0842\ mole\ Sn$$

$$\frac{0.158mole\ I2}{2\ mole\ I2} = 0.0788\ mole\ I2$$

Because I_2 is a smaller number than Sn, I_2 is the limiting reagent.

Complete using a separate sheet of paper:

1. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:

Fe (s) + S (l) → FeS (s)

In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.

a) What is the limiting reagent, and what is the reactant in excess?

b) Calculate the mass of FeS formed.

3. Methane (CH_4) burns in air (reacts with O_2) to form carbon dioxide (CO_2) and water vapor (H_2O). If 20 g of CH_4 was mixed with 30 g of O_2 in a closed container and ignited:

a) What would be the limiting reagent?

b) How much excess reagent would be left over?

c) How much CO_2 would be made?

d) How much H_2O would be made?

4. When 7.24 moles of magnesium solid and 3.86 moles of oxygen gas react to form magnesium oxide solid, which reactant will be left over? How much of the excess reactant will remain?

5. When 1.00 g zinc metal is placed in 25 ml of a solution made with 5 g lead (II) nitrate, a single displacement reaction occurs to produce crystals of lead and zinc nitrate. Which reactant is in excess? How many grams of lead will be formed?

6. If 7.56 g of iron metal are placed with 0.1 moles of hydrochloric acid solution (HCl), hydrogen gas and iron (II) chloride are produced. Which reactant is limiting, and how much excess of the other reactant is there? Then calculate the grams of each product.

Limiting Reagent sheet 2

1. Given the following reaction: (Balance the equation first!)

$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

a) If you start with 14.8 g of C_3H_8 and 3.44 g of O_2, determine the limiting reagent
b) determine the number of moles of carbon dioxide produced
c) determine the number of grams of H_2O produced
d) determine the number of grams of excess reagent left

2. Given the following equation:

$Al_2(SO_3)_3 + 6\ NaOH \rightarrow 3\ Na_2SO_3 + 2\ Al(OH)_3$

a) If 10.0 g of $Al_2(SO_3)_3$ is reacted with 10.0 g of NaOH, determine the limiting reagent
b) Determine the number of moles of $Al(OH)_3$ produced
c) Determine the number of grams of Na_2SO_3 produced
d) Determine the number of grams of excess reagent left over in the reaction

3. Given the following equation:

$Al_2O_3 + Fe \rightarrow Fe_3O_4 + Al$

a) If 25.4 g of Al_2O_3 is reacted with 10.2 g of Fe, determine the limiting reagent
b) Determine the number of moles of Al produced
c) Determine the number of grams of Fe_3O_4 produced
d) Determine the number of grams of excess reagent left over in the reaction

Limiting Reagent Sheet #3

1. Consider the reaction

$$I_2O_5(g) + 5\ CO(g) \rightarrow 5\ CO_2(g) + I_2(g)$$

a) 80.0 grams of iodine(V) oxide, I_2O_5, reacts with 28.0 grams of carbon monoxide, CO. Determine the mass of iodine I_2, which could be produced?

b) If, in the above situation, only 0.160 moles, of iodine, I_2 was produced.

i) what mass of iodine was produced?

ii) what percentage yield of iodine was produced.

2. Zinc and sulphur react to form zinc sulphide according to the equation.

$$Zn + S \rightarrow ZnS$$

If 25.0 g of zinc and 30.0 g of sulphur are mixed,

a) Which chemical is the limiting reactant?

b) How many grams of ZnS will be formed?

c) How many grams of the excess reactant will remain after the reaction is over?

3. Which element is in excess when 3.00 grams of Mg is combusted in 2.20 grams of pure oxygen? What mass is in excess? What mass of MgO is formed?

4. How many grams of Al_2S_3 are formed when 5.00 grams of Al is heated with 10.0 grams S?

5. When MoO_3 and Zn are heated together they react

$$3\ Zn(s) + 2\ MoO_3(s) \rightarrow Mo_2O_3(s) + 3\ ZnO(s)$$

What mass of ZnO is formed when 20.0 grams of MoO_3 is reacted with 10.0 grams of Zn?

6. Silver nitrate, $AgNO_3$, reacts with ferric chloride, $FeCl_3$, to give silver chloride, AgCl, and ferric nitrate, $Fe(NO_3)_3$. In a particular experiment, it was planned to mix a solution containing 25.0 g of $AgNO_3$ with another solution containing 45.0 grams of $FeCl_3$.

a) Write the chemical equation for the reaction.

b) Which reactant is the limiting reactant?

c) What is the maximum number of moles of AgCl that could be obtained from this mixture?

d) What is the maximum number of grams of AgCl that could be obtained?

e) How many grams of the reactant in excess will remain after the reaction is over?

7. Solid calcium carbonate, $CaCO_3$, is able to remove sulphur dioxide from waste gases by the reaction (balanced as written):

$$CaCO_3 + SO_2 + \text{other reactants} \rightarrow CaSO_3 + \text{other products}$$

In a particular experiment, 255 g of $CaCO_3$ was exposed to 135 g of SO_2 in the presence of an excess amount of the other chemicals required for the reaction.

a) What is the theoretical yield of $CaSO_3$?

b) If only 198 g of $CaSO_3$ was isolated from the products, what was the percentage yield of $CaSO_3$ in this experiment?

Answer key

Sheet 2

1. Balanced equation:

$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

a) O_2 b) 0.065 mol CO_2 c) 1.56 g H_2O d) 13.86 g C_3H_8

2a) $Al_2(SO_3)_3$ b) 0.068 mol $Al(OH)_3$ c) 12.85 g Na_2SO_3 d) 1.84 g NaOH

3. Balanced equation:

$4\ Al_2O_3 + 9\ Fe \rightarrow 3\ Fe_3O_4 + 8\ Al$

a) Fe b) 0.16 mol Al c) 14.12 g Fe_3O_4 d) 17.13 g Al_2O_3

Sheet 3

1. a) CO L.R. 50.7g I2 b) i) 40.6g ii) 80.1%
2. Zn 0.3803mol S 0.9356mol a) Zn b) 37.1g c) 17.7g
3. O2, 0.226g excess O2, 4.97g MgO
4. Al L.R. 13.9g Al_2S_3
5. Zn L.R., 12.4g ZnO
6. a) $AgNO_3$+ $FeCl_3$→3AgCl+ $Fe(NO_3)_3$b) AgNO3 c) 0.147mol d) 21.1g e) 37.1g FeCl3
7. SO_2 a) 253g b) 78%